Facilitating E-Learning through Mobile Ad Hoc Networks

Deepshikha Aggarwal*

Abstract

The rapid and accelerating move towards the adoption and use of mobile technologies has increasingly provided students and teachers with the ability to study away from the classroom and on the move. Wireless and mobile technologies influence the evolution of current e-learning use and press forward the development of new mode of education enabling any time, anywhere and anyhow learning. New wireless technologies can be used to boost interactivity, thus helping create community, as people remain online even while going about their business. The use of wireless technology paves the way for a literal interpretation of mobile ubiquitous computing. People can get online, be reached, and interact anywhere and anytime. In this paper, we discuss a platform based on wireless technologies to support learning communities in university campuses and how it could be used to improve ubiquitous interactivity and cooperation among teachers and students. The requirements of modern e-learning techniques change. Aspects such as community interaction, flexibility, pervasive learning and increasing mobility in communication habits become more important. To meet these challenges e-learning platforms must provide support on mobile learning. Most approaches try to adopt centralized and static e-learning mechanisms to mobile devices. However, often technically it is not possible for all kinds of devices to be connected to a central server. Therefore we introduce an application of a mobile e-learning network which operates totally decentralized with the help of underlying ad hoc network architecture.

Keywords: MANET, learning community; wireless technologies; mobile and ubiquitous computing. Mobile learning, ad hoc learning, community, e-learning platform, ad hoc messaging network, pervasive learning

Introduction

In computer networking, an ad hoc network refers to a network connection established for a single session and does not require a router or a wireless base station. Basically, an ad hoc network is a temporary network connection created for a specific purpose (such as transferring data from one computer to another) [Tanenbaum, A. 2003]. A MANET (Mobile Ad hoc NETwork) is a type of ad hoc network that can change locations and configure itself on the fly. Because MANETS are mobile, they use wireless connections to connect to various networks. This can be a standard Wi-Fi connection, or another medium, such as a cellular or satellite transmission. Some MANETs are restricted to a local area of wireless devices (such as a group of laptop computers), while others may be connected to the Internet [M. Berger und M. Watzke 2001]. For example, A VANET (Vehicular Ad Hoc Network) is a type of MANET that allows vehicles to communicate with roadside equipment. While the vehicles may not have a direct Internet connection, the wireless roadside equipment may be connected to the Internet, allowing data from the vehicles to be sent over the Internet. The vehicle data may be used to measure traffic conditions or keep track of trucking fleets. Because of the dynamic nature of MANETs, they are typically not very secure, so it is important to be cautious what data is sent over a MANET. Mobile ad-hoc networks are characterized by spontaneously connecting systems using wireless technologies. Such networks have inherently high dynamics, because mobile terminals can randomly enter or leave the reachability scope at any time. Besides the dynamic changes in the infrastructure itself, there are also dynamic changes in provided services, content and reachable users within the ad-hoc network.

Deepshikha Aggarwal*
Jagan Institute of Management Studies,
Delhi

With the vast development of various technologies, learning today is no long confined in classrooms with lecture as the only method for conveying knowledge . E-learning, which facilitates education using a network, has made learning possible from anywhere at any time by using the Internet, wide area networks, or local area networks. Specially, mobile learning even allows people to learn on the move using portable devices, such as cell phones, personal digital assistants (PDAs), or laptops.

Motivation For Research

More and more people are equipped with more or less powerful mobile computers, ranging from cell phones to laptops. Over the last couple of years, research on ad-hoc networks as a means to provide technical integration of these devices has attracted a lot of attention. An ad-hoc network is a dynamic collection of mobile devices that are connected without a fixed infrastructure. In single hop ad-hoc networks, all the devices are within radio range of each other and can communicate directly. Usually, however, interesting resources and services are spread across a wider range. What is needed then, are multi-hop ad-hoc networks, where devices can communicate with one another by "routing" information through intermediate nodes. They now become themselves part of the infrastructure. In particular, the nodes have to act as routers if needed. So far, the technical side of ad-hoc networks has received much attention from the research community. For example, they may wish to share the information available in a network. This integrated usage of resources is quite common in fixed networks and even in infrastructure-based wireless networks. There exist a lot of concepts and mechanisms to support integrated access to shared resources. Very little has been done in the rather new research field of ad-hoc networks. Moreover, there is no straightforward adaptation of the existing solutions to networks that change their structure dynamically and have no dedicated components for building an infrastructure. It should be quite obvious that support for information sharing (or more generally for resource sharing) is needed, if these networks are to be widely used [www.ellinogermaniki.gr/ep/ad-hoc]. Therefore in this paper, we develop concepts to use the resources of an ad-hoc net in an integrated, effective and efficient way. Resources are shared by offering services that allow access to them. Our special interest lies on services offering access to information. These services can be viewed as a large, highly heterogeneous, distributed information system with autonomous component systems. Our goal is to support the effective and efficient usage of these resources. On the one hand, mechanisms to use the provided resources *effectively* assure that the resources yield the desired results, i.e. that the services we find and use do what we expect them to do. On the other hand, mechanisms to use the resources *efficiently* help to gain the results in a resource-aware manner, i.e. with as little resource consumption as possible. Another major contributor to the changing face of e learning is Web 2.0[http://www.ietf.org/html.charters/manet-charter.html]. Educators began to notice something different happening when they began to use tools like wikis and blogs in the classroom. All of a sudden, instead of discussing pre-assigned topics with their classmates, students found themselves discussing a wide range of topics with peers worldwide. In a very short time, blogs were used for a wide variety of purposes in education; an educational bloggers' network formed and thousands of teachers were encouraging their students to blog.

New Challenges In E-learning

E-learning is of an increasing importance in modern education systems. Therefore, methods and content of e learning changes and sets new challenges for technical and social tasks. New aspects arise of how people deal with information, how they expect to be provided with content and in what situations and places they want to learn. Furthermore community learning is a new approach and focuses on interaction aspects between people. Modern e-learning platforms have to reflect on these new challenges [J. Fleischman 2001]. Our approach is to focus on different applications for e-learning solutions to meet these challenges. One of the most important strategies for mobile e-learning is to focus on ubiquitous learning, communication in dialogues, and connectivity to meet the arising community aspects of learning platforms.

Learning is not bound to courses, time, and places. Many situations during a day can be seen as individual

learning environments. The term 'ubiquitous learning' describes learning environments as they are: pervasive and omnipresent. Combining pervasive learning and mobile learning will bring up ubiquitous learning.

Knowledge gains takes place in close interaction among members of social networks. That can be in a common teaching environment such as a course, a group of friends that share the same interests or just in transient everyday situations [C. Fuch, S. Stieglitz, and O. Hillmann, 2006]. As a personal learning experience former foreign knowledge is added to ones own knowledge repository. This knowledge content represents potential learning items for other participants of the learning group or course. As knowledge is not a rare resource, knowledge can easily be shared among members in a social group. Thus gaining of knowledge in groups is not only profitable for one member but also for other members or for the whole group. Networks effects become important and accelerate the learning process.

Using mobile devices can support the broadcasting of experiences to a larger group. The messages may be time shifted but still the content is shared. Therefore the devices must offer various interfaces for different situation to be capable of the exchange of parts of knowledge repository anytime and in any situation. In order to make content on various devices accessible for end users, a unified communication service platform must be introduced. Message sharing should rely on standard interfaces and should be transparent to the applications that end users operate with.

Implementation Of Manets For Elearning

The vision of mobile computing is that of portable computation with rich interactivity, total connectivity, and powerful processing. This small device is always networked, allowing easy input through pens and/or speech or even a keyboard when necessary (though it may be something completely different like a chord keyboard), and the ability to see high resolution images and hear quality sound. It may be that the image is overlaid on the world through glasses that act like a Heads up Display. Mobile learning can be considered from two viewpoints, the first one is technical oriented perspective regard traditional behaviouristic educational paradigm as given and tries to represent or to support them with mobile technologies. A main concern from this perspective is how to create, enrich, distribute and display learning material on mobile devices; the main benefits are to personalize the way of learning (where you want, when you want, what you want, as fast as you want, how you want; etc). The second one is pedagogical socio-cognitive and distributed cognition paradigms [Yu-Han Chang, 2004]. In this viewpoint we face traditional designs of teaching and learning to push community oriented learning like collaborative learning, problem based learning; informal and ad-hoc learning, etc.

Most of e-learning arrangements focus on individual learning experiences. Participants are able to choose time and place where they want to precede the lessons. However, even in traditional leaning arrangements, where learning takes place in courses and leaning groups, knowledge is spread among the group members and the net outcome, respectively the resulted knowledge gain for the group is greater than the sum of the individual gains due to network effects. E-learning may not reject those advantages and concentrate on community aspects as well. Tools that support knowledge management in learning communities can be internet or intranet portals, wiki installations, forum software, classical online learning platforms, or other web 2.0 applications. The success of these applications, especially wikis and forums, strongly depends on network effects. The benefit for every single user who is contributing in such a community rises with the amount of members and the amount of postings. Usually, in common learning environments there is a limited number of participants [*Chang, C.Y., Sheu, J.P., Chan, T.W., 2003*]. Therefore, network effects could hardly be realized. In many situations the need of being connected to a central server is a limiting factor for the growth of an e learning community. Thus it is necessary to provide a network platform that can be used by members anywhere and anytime without the need of being connected to a central server. Most important is the way of communication that is used among participants sharing content without a continuous connection to the central repository. Mechanisms of ad hoc networking are used for off-course knowledge distribution.

E-learning Scenario in a University Campus

In order to see how e learning works in an ad hoc network, we would set up an imaginary MANET of a university campus. A MANET consists of autonomous mobile nodes that are free to roam arbitrarily with no centralized controller such as router to determine the communication paths[Royer, E., Chai Keong Toh , 1999]. Each node in the ad hoc network has to rely on each other in order to forward packets. This kind of nature of MANET requires mobile nodes to have good cooperation with each other to ensure that the initiated data transmission process is a success. This network is independent of any fixed infrastructure or centralized administration. A node communicates directly with nodes within its wireless communication range. Nodes that are part of the MANET, but beyond each other's wireless range communicate using a multi-hop route through other nodes in the network. These multi-hop routes changes with the network topology and are determined using a routing protocol. A node in an IP-based network is configured with an IP address, a net-mask and a default gateway (the node to which packets for destinations not having an explicit entry in the routing table are sent). In a MANET, nodes should be able to enter and leave the network at will. Thus, the nodes should be capable of being dynamically configured by the network upon their entry into it. It may be argued that MANET nodes also belong to some home network, and could continue to use their home network IP address in the MANET. However, in several instances a node does not permanently own an IP address: an IP address is assigned to the node when it boots up, and the node releases it on leaving the network.

For example user1, is a computer science student. She is currently preparing for her exam on "Information Systems". This exam covers several topic areas like "Software Engineering", "DBMS", "Computer Networks", and so on. At a particular time, she is at the campus cafeteria. She has brought her PDA along so that she can continue working. Before leaving home, she has downloaded the PowerPoint slides describing the two-phase commit protocol onto her PDA. After working through a few slides, she comes across an annotation mentioning a paper that explains a specific aspect in more detail. User1 tells her PDA that it should try to locate the paper somewhere and download it. User1 PDA is not connected to a fixed network. However, her PDA forms an ad-hoc network together with other nearby computers. Some of these computers (or rather their users) will have similar interests as User1 and might thus be able to provide the required information. Eventually User1 PDA finds another computer that not only possesses the paper in question but is also willing to allow downloading it. User1 works through the paper and then returns to the original slides. Even after going through all of them, she is not sure that she has quite understood what 2PC is all about and feels that an example would greatly help her understanding. She asks the PDA to look for an example. It reports that the introductory course on database management provides just that. The PDA also determines that while none of the computers currently participating in the ad-hoc network has stored the example, a computer that offers access to the fixed network has just joined. User1's PDA uses this computer's network connection to retrieve the example.

Let us now take a look at the requirements that need to be met in order to offer the desired functionality. Obviously, we need a possibility to spontaneously network any computers without having to rely on a fixed infrastructure. Thus, the technical basis of the system should be formed by an ad-hoc network. However, this technical basis alone is not sufficient to efficiently use the network. Additional functionality is needed that allows finding and using resources in the network. In particular, concepts are needed to address the following topics:

- Service description. Services need to be described so that they can be found automatically. In order to achieve this, a merely syntactic description of the service interface is not sufficient.
- Representation of the user context. The current context of the user, e.g. her location, the computer she is using and the state it is in, her interests and so on, plays an important role in determining which services are suitable to address her needs.
- Service discovery. In ad-hoc networks, the set of services that is available at any given time cannot be predetermined to be static, as the participating

computers change frequently. Thus, a mechanism is needed that helps users to find the services they need.

- Efficient usage of services. Depending on the current structure of the network and the state of the computers that form it, strategies for efficient usage of services need to be developed.
- Integration of services. Often, one service alone will not be able to answer a user request. What is needed is rather a combination of different services that together offer the required functionality.
- Motivation to offer services. The network needs to offer some kind of incentive to participating computers to offer services. An appropriate means has to be devised.

The basic building blocks of our solution are services. A wide range of different services will be offered and used by the participants in our ad-hoc network. Services are described by service descriptions based on the developing standards in this area. These descriptions are used for a service discovery mechanism. Since ad-hoc networks do not possess any infrastructure components of their own, service discovery needs to be organized in a distributed fashion by the participating nodes. Once services have been discovered they should be used efficiently and effectively in a resource-aware manner.

Advantages of Mobile Learning

The most obvious advantage of a learning environment is the ability to access information where it would not be possible without a mobile device. Mobile devices belong to a learner's personal sphere [Wenger, E., R. McDermott, and W. M. Snyder, 2002]. This means the learner can take learning opportunities directly in the situation where they occur, because he has his learning environment always at hand. Mobile learning, offers the possibility to arrange learning settings flexibly and spontaneously, helps organizational skills , encourage a sense of responsibility, helps both independent and collaborative learning, and can be used to help track students' progress and for assessment. Students and teacher can jump from an individual work, to a group work, to a classroom work, they can also change place without modifying the material. The Ad Hoc system will fulfill the following general requirements:

- Interactivity: It should provide means of communication between learners and teachers. It should allow for feedback by the teachers that will be accessible to learners.
- Interdisciplinary: Content should be presented in an interdisciplinary way incorporating information of different disciplines, thus promoting the idea of informal learning.
- Unobtrusiveness: So that the student can capture situations and retrieve knowledge without technology obtruding on the situation.
- Availability: Its functions should be available anywhere and it should provide seamless communication inside and outside buildings.
- Adaptability: It should adapt to the learners' evolving skills and knowledge.
- Usefulness: It should be suited to everyday needs for communication, reference, and learning
- Suitability: Content should be corresponding to specific learning needs of users, e.g. content for the same subject should be presented in several ways and provided according to the specific users' profile;
- Easy to use: It should be intuitively easy to use, by users with no computer experience.

The increased requirement to maintain a competitive advantage in the global economy has resulted in deliberate personal learning. This potential is likely to increase as the information age accelerates. People will need to be able access information faster and more effectively if they are to increase their employability, business success, personal fulfillment and social development. Mobile Learning provides people with the opportunity to access information where it would previously have been impossible. This access advantage is not limited to time and location. The devices required to access mobile networks are relatively inexpensive compared to desktop or laptop computers. This reduced expense can make access to this learning available to people who otherwise could not afford it.

Ad Hoc Networking Issues

In general, mobile ad hoc networks are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using the existing network infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily; thus, the networks wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Mobile ad hoc networks are infrastructure-less networks since they do not require any fixed infrastructure, such as a base station, for their operation. In general, routes between nodes in an ad hoc network may include multiple hops, and hence it is appropriate to call such networks as "multi-hop wireless ad hoc networks". Each node will be able to communicate directly with any other node that resides within its transmission range. For communicating with nodes that reside beyond this range, the node needs to use intermediate nodes to relay the messages hop by hop. The ad hoc networks flexibility and convenience do come at a price. Ad hoc wireless networks inherit the traditional problems of wireless communications and wireless networking:

- the wireless medium has neither absolute, nor readily observable boundaries outside of which stations are known to be unable to receive network frames;
- the channel is unprotected from outside signals;
- the wireless medium is significantly less reliable than wired media;
- the channel has time-varying and asymmetric propagation properties;
- Hidden-terminal and exposed-terminal phenomena may occur.

To these problems and complexities, the multihop nature, and the lack of fixed infrastructure add a number of characteristics, complexities, and design constraints that are specific to ad hoc networking:

- *Autonomous and infrastructure-less:* MANET does not depend on any established infrastructure or centralized administration. Each node operates in distributed peer-to-peer mode, acts as an independent router and generates independent data. Network management has to be distributed across different nodes, which brings added difficulty in fault detection and management.
- *Multi-hop routing:* No default router available, every node acts as a router and forwards each others packets to enable information sharing between mobile hosts.
- *Dynamically changing network topologies*: In mobile ad hoc networks, because nodes can move arbitrarily, the network topology, which is typically multi-hop, can change frequently and unpredictably, resulting in route changes, frequent network partitions, and possibly packet losses.
- *Variation in link and node capabilities:* Each node may be equipped with one or more radio interfaces that have varying transmission/receiving capabilities and operate across different frequency bands. This heterogeneity in node radio capabilities can result in possibly asymmetric links. In addition, each mobile node might have a different software/hardware configuration, resulting in variability in processing capabilities. Designing network protocols and algorithms for this heterogeneous network can be complex, requiring dynamic adaptation to the changing conditions (power and channel conditions, traffic load/distribution variations, congestion, etc.).
- *Energy constrained operation:* Because batteries carried by each mobile node have limited power supply, processing power is limited, which in turn limits services and applications that can be supported by each node. This becomes a bigger issue in mobile ad hoc networks because, as each node is acting as both an end system and a router at the same time, additional energy is required to forward packets from other nodes.
- *Network scalability:* Currently, popular network management algorithms were mostly designed to work on fixed or relatively small wireless networks. Many mobile ad hoc network applications involve large networks with tens of thousands of nodes, as found for example, in sensor networks and

tactical networks. Scalability is critical to the successful deployment of these networks [Mauve, M., Widmer, J., Hartenstein, H., 2001]. The steps toward a large network consisting of nodes with limited resources are not straightforward, and present many challenges that are still to be solved in areas such as: addressing, routing, location management, configuration management, interoperability, security, high capacity wireless technologies, etc.

Conclusion and Future Scope

Life long learning will be essential for maintaining a competitive advantage in the global economy, for personal growth, and for simply functioning efficiently in an increasingly technological environment. With an increasing requirement to conduct learning activities independently, the ability to read and comprehend, and to analyze and understand our learning processes, will be key factors in our successful development. These requirements and skills can be improved through the use of Mobile Learning. It provides access to learning during previously unproductive times, it allows more flexible and immediate collaborative options, it allows controlled learning in contextual situations, and provides greater options for teachers to observe and assist in independent learning.

The use of MANETs for education considers that the challenge for the future generation of educational systems is to develop environments for mobile phones and mobile computers as the availability of mobile devices spreads to a billion of users. The mobile telephone is becoming a trusted, personal device with Internet access, smart card usage, and a range of possibilities for keeping the learner in touch with the institution's student support services, in contact with learning materials and fellow students, while at home, at work or travelling. E-learning can be a learning method for rural people. Basic idea behind the e-learning is interactivity. It can be best method to teach people of rural areas especially from remote areas which are neglected regarding education. Structural education system is also absent there. Though rural areas are out of ICT infrastructure, in recent years, the proliferation of mobile computing devices has driven a revolutionary change in the computing world. The nature of the ubiquitous devices makes wireless networks the easiest solution for their interconnection. This has led to the rapid growth of several wireless systems like wireless ad hoc networks, Wireless sensor networks etc. In this paper, we describe a learning system using ad hoc networks which can be further extended to rural areas that would allow resource-starved village schools in rural India to benefit from the better human and content resources available in the urban environments. The idea is to cover and support people from rural and remote areas through wireless ad hoc networks. Every village as well as rural area will be connected to the mobile access point. This will bridge the gap between people of rural area and education system and we will be able to provide e-learning. In this way we will be able to provide education to maximum people in a country in an interactive way. The e-learning landscape is littered with misguided and expensive "wire-the-schools" projects that have little to show for in the end. To avoid retracing these missteps, we must follow at least two important principles in our solution: cost realism, which is essential if we were to scale up the system to encompass a large number of villages, schools, and students in the long run; and building systems that solve end-to-end education problems, instead of narrowly focusing on just providing connectivity.

References

1. C. Fuch, S. Stieglitz, and O. Hillmann (2006), "Ad-hoc Messaging Network in a Mobile Environment," presented at *International Conference of Internet Technology and Secured Transactions*, London.
2. *Chang, C.Y., Sheu, J.P., Chan, T.W. (2003)*, "Concept and Design of Ad Hoc and Mobile Classrooms". *Journal of Assisted Learning*, 19, 336–346.
3. http://www.ietf.org/html.charters/manet-charter.html

4. J. Fleischman (2001), "Going Mobile: New Technologies in Education", *Converge Magazine* found at *www.convergemag.com*

5. M. Berger und M. Watzke (2001), "Ad-hoc FIPA Work Plan" found at *http://www.fipa.org/docs/wps/f-wp-00014/f-wp-00014.html*

6. Mauve, M., Widmer, J., Hartenstein, H. (2001). "A Survey on Position-Based Routing in Mobile Ad Hoc Networks". *IEEE Network.*

7. Royer, E., Chai Keong Toh (1999). "A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks". *IEEE Personal Communications.*

8. Tanenbaum, A. (2003), *Computer Networks*, Prentice-Hall, New Delhi.

9. W3C Working Group on "Composite Capabilities Preferences Profile" found at *http://www.w3.org/Mobile/CCPP/*

10. Wenger, E., R. McDermott, and W. M. Snyder, (1st Ed) (2002), "Cultivating Communities of Practice: A Guide to Managing Knowledge". *Harvard Business School Press.*

11. www.ellinogermaniki.gr/ep/ad-hoc.

12. Yu-Han Chang (2004), "Mobilized ad-hoc networks: A reinforcement learning approach", *Proceedings of International Conference on Autonomic Computing*, 240-247.